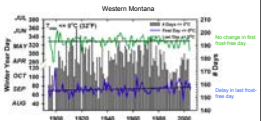
Section 4: Phenology

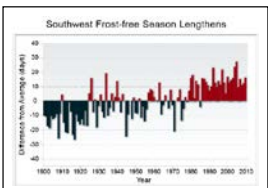
Learning outcomes

- understand what phenology is and what mechanisms are involved
- give examples of how climate change has affected phenology in species
- explain how changes in phenology affect species interactions

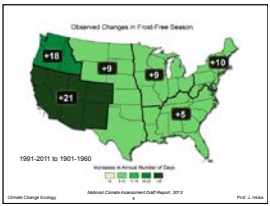
Changes in climate that affect phenology



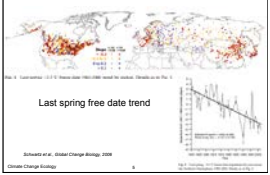
Pederson et al. 2010



National Climate Assessment Draft Report, 2013



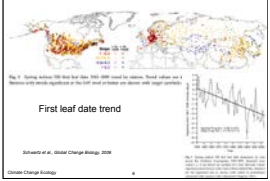
Changes in climate that affect phenology



Last spring free date trend

Schwartz et al., Global Change Biology, 2006

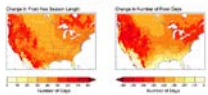
Changes in climate that affect phenology



First leaf date trend

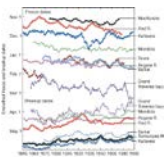
Schwartz et al., Global Change Biology, 2006

Projected changes in 2100 under A2 scenario



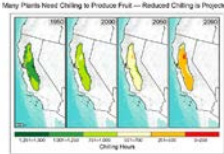
National Climate Assessment Draft Report, 2013

Changes in ice formation, breakup



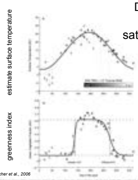
What are the implications for plants, animals?

Many Plants Need Chilling to Produce Fruit — Reduced Chilling is Projected



National Climate Assessment Draft Report, 2013

Defining vegetation phenology using satellite remote sensing



T used to identify outliers that are then weighted less

Fischer et al., 2006

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•Chilling
•Photoperiod
•Temperature
•Chilling
•Temperature
•Temperature
Fagus
Carpinus
Syringa
Not just temperature. Spring development in many ornamental plants from warm regions, such as lilac (Syringa), is primarily controlled by temperature, whereas early successional species native to temperate latitudes, such as hornbeam (Carpinus), only become temperature sensitive once their chilling demand has been fulfilled. Late successional taxa, such as beech (Fagus), are photoperiod controlled, with temperature only exerting a limited modulating effect once the critical day length has passed. This mechanism prevents such taxa from sprouting at the "wrong" time.

Körner and Basler, Science, 2010

Climate Change Ecology 11 Prof. J. Hicke

Plant development

Common name	Latin name	Number of growing degree days (baseline 10 °C)
[illegible]	[illegible]	[illegible]

en.wikipedia.org/wiki/Growing-degree_day

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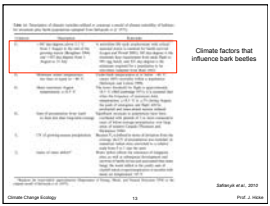
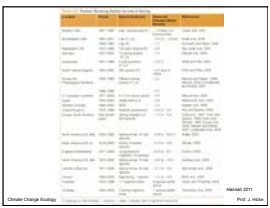


Climate factors that influence bark beetles

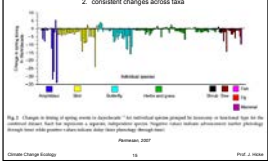
Safaryk et al., 2010



Hannah 2011

Meta-analysis of spring phenology

1. almost all are advances
2. consistent changes across taxa



Parmesan, 2007

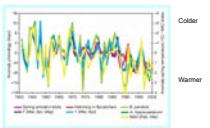
Spring warming => biological responses

Later

Earlier

Colder

Warmer



Walther et al., 2002

Climate Change Ecology

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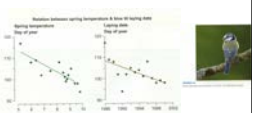
Warming and laying date



Hannah 2011

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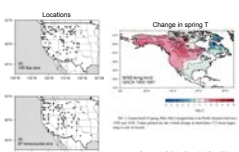
Lilac and honeysuckle first bloom dates

Locations

Change in spring T



Cayan et al., Bulletin of Amer. Met. Soc., 2001

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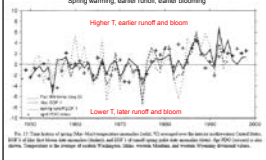
Lilac and honeysuckle first bloom dates

Spring warming, earlier runoff, earlier blooming



Cayan et al., *Bulletin of Amer. Met. Soc.*, 2001

Lilac and honeysuckle first bloom dates

Analysis of lilac first bloom dates in Spokane

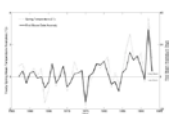
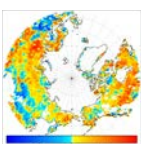


Figure from V. Jansen, UI, climateimw.wordpress.com/2012/05/29/the-lilac-city-and-spring-phenology/

Satellite-derived increases in growing season length

1982-2005



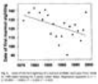
Smith-Downey et al., 2009

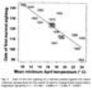
National Climate Assessment: Biological Responses

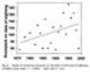
2. N. Flickers arrive earlier, lay eggs earlier due to warming
8. RM high-elevation areas: Flower phenology changes; declines in flower resources that may affect pollinators; earlier growth led to higher susceptibility to frost; decoupling plant/pollinator interactions with earlier plant phenology compared with insects; all due to warming
11. Earlier first flowering dates in 40% of 178 plant species examined; warming
14. Earlier arrival dates of 36% of 44 species of migratory birds; warming in winter
20. Arrival times of amphibians to breeding sites:
    - autumn breeders: later
    - winter breeders: earlier
    - warming nighttime T and precip

Staudinger, et al. Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment, 2012

Climate change may lead to seasonal mistiming



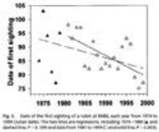




Consequences for marmot???

Inouye et al., 2000

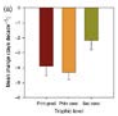
Climate change may lead to seasonal mistiming



Inouye et al., 2000

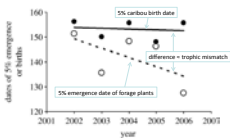
Differential changes among trophic levels

Secondary consumers not advancing as quickly



Thackeray et al., GCB, 2010

Post and Forchhammer (2008) Climate change reduces reproductive success of an Arctic herbivore through trophic mismatch



Slide courtesy J. Lichstein, U. FL